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A PLAN FOR ECOLOGICAL RESEARCH

Submitted to

THE INSTITUTE FOR NORTHERN STUDIES

University of Saskatchewan

Saskatoon, Canada

STUDIES ON THE VEGETATION OF

NORTH CENTRAL CANADA

by

Ralph L. Dix and Robert T. Coupland

Department of Plant Ecology

in cooperation with

Taylor A. Steeves, Department of Biology

Margaret W. Steeves, Department of Geology

University of Saskatchewan

December, 1961

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I. INTRODUCTION

Natural vegetation provides a reliable index to the present climate of a region and offers intelligible evidence as to climatic changes through recent geological time. In a frontier region such as northern Saskatchewan where weather stations are scarce, scattered and of recent establishment, natural vegetation provides the best, and in many cases the only, data which permit the making of reasonable estimates of the region's biotic productivity and potential. In order to gather data on the vegetation of north central Canada, the Department of Plant Ecology, with financial support from The Institute for Northern Studies, initiated in 1960 an extended ecological probe into the forested areas of Saskatchewan, extending from Waskesiu (lat. 54°) in the south to Stony Rapids (lat. 59°) in the north. This action was continued in an expanded fashion through the summer of 1961. The data collected and the experience gained in this initial activity make it clear that, due to the complexities of the ecological problems involved and to the difficulties and expense of travel and supply in regions north of the road system, further work would benefit greatly by long-term planning. Further, the phytoecological work has pointed up the desirability of early participation by other botanical disciplines and the plan outlined here has been drawn up in cooperation with a taxonomist, a morphologist and a paleobotanist. These investigators have agreed to participate in the program.

It is our purpose here to outline a long-term plan which, when implemented, will form the basis for an orderly and efficient examination and analysis of the natural vegetation occupying northern Saskatchewan and the adjacent Provinces and Territories. The need for such a program lies in the fact that ecological studies to date in this region are few in number and of necessity have been superficial in nature. The plan described here includes only the first five years of a more comprehensive program which has as its objective an exhaustive treatment of the vegetation of north central Canada.

The plan is designed to cover a period from the Spring of 1962 to the Spring of 1967.

II. STUDY PLAN

The desirable order for the study of the natural vegetation of a region is to determine: (A) the phytosociological distribution of its taxa - the geographic and physiographic occurrences of its taxa and their behaviour along climatic and edaphic gradients; (B) the taxa themselves - their taxonomic status and autecological characteristics; and (C) its paleoecological history. Phytosociological investigations on the numerical relationships between the taxa occupying a region should precede other work for the ordination of these data establish a framework upon which organized and therefore more efficient research may be planned. The establishment of natural groupings of taxa enables the autecological characteristics and genetic variations of such groupings to be studied simultaneously with a resulting saving in time and expense. Further, information on the autecological characteristics and taxonomic position of the taxa in the flora will greatly increase the accuracy and therefore the reliability of inferences drawn from paleoecological studies of organic sediments.

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While the priority given here appears to be the most efficient, materials collected and concepts formed in the early parts of the work may necessitate some alterations in the

program. For example, voucher specimens collected in the phytosociological work may bring to light taxonomic problems which can be investigated with profit to the phytosociological work. Thus, while the emphasis in the early stages of the program will be on phytosociology, it will be desirable to initiate work in other areas before the phytosociology is completed.

A. Phytosociological studies. Ralph L. Dix and Robert T. Coupland

In keeping with the principles stated above phytosociological studies were initiated in the summer of 1960 and were continued through the summer of 1961. Forest stands were quantitatively sampled for species composition of trees, shrubs, herbs, and mosses, and these data are now being statistically evaluated in the laboratory of the Department of Plant Ecology. Data were collected in 98 stands located at four widely separated positions in the Boreal Forest. Thirty-two stands were sampled in the vicinity of Lac la Ronge, 31 near Cree Lake, 26 near Stony Rapids (all in Saskatchewan) and 9 near Small Tree Lake (Northwest Territories). While the data collected in these initial studies represent the most detailed phytosociological analysis to be made in the Boreal Forest of this area, they nevertheless must be considered inadequate and preliminary. The stands are located over a distance of approximately 500 miles and sampling was limited, because of travel difficulties, to stands aggregated around the four widely separated areas given above. As valuable as these data are, more must be done to fill in the conspicuous gaps between the sample locations.

In the light of the experience provided by the past two summers, the most efficient procedure for further phytosociological studies in the forest areas is to initiate detailed studies on more local regions within the Boreal Forest. It is thought advisable to begin the studies along the southern edge of the Forest where travel is less restricted and comparatively inexpensive and to extend the work northward armed with the information gained in the south. The work will be divided into five separate but closely related studies, each done independently but under the general supervision of the faculty of the Department of Plant Ecology. The five projects are as follows:

Upland Forest

1. The southern edge of the Boreal Forest.
2. The central Boreal Forest.
3. The northern edge of the Boreal Forest.

Lowland Forest (muskegs)

4. The southern lowland forest.
5. The northern lowland forest.

The personnel required to implement this phase of the work includes one research assistant (presumably a recent Ph.D. graduate) and five graduate students. The research assistant is needed to give continuity to the field work by teaching newly arrived graduate students the local flora, the particular phytosociological methods to be employed and to assist with problems which may arise while no faculty member is present in the field. Further, since large sections of the region under investigation are remote and largely uninhabited,

and since most graduate students will come to us without previous experience at living in the bush, the research assistant will be of great value in assisting the new students in the adjustment to camp life and the ways of the North.

The plan provides for the research assistant and two graduate students to begin phytosociological studies in the spring of 1962 — approximately May 15th. One graduate student will be assigned to each of the following problems: (1) The southern edge of the Boreal Forest and (4) The southern lowland forest.

In the second and third years of the program, additional students will be assigned to complete the phytosociological phase of the program by doing problems: (2) The central Boreal Forest; (3) The northern edge of the Boreal Forest; and (5) The northern lowland forest. If it seems advisable at that time, the phytosociological phase may be extended into the Tundra, but for practical considerations this decision is postponed and no provision is made for it in this budget.

B. The Taxa

A taxon is a category usedin the classification of biotic units. It is a natural population or a system of populations of genetically related individuals of any taxonomic rank (species, genera, division, etc.). It is the purpose of the studies described in this section of the plan to analyze the taxonomic and autecological characteristics of the plant populations (the taxa) occurring in the Boreal Forest of north central Canada.

B_1. Taxonomic Studies. In cooperation with the Curator, W.P. Fraser Herbariu

The flora of north central Canada, in comparison to the floras of regions to the south, is composed of a relatively small number of recognized plant species. Because there are few species, those which are able to survive have a wide variety of habitats available to them and competition between ecotypes, interspecific competition, is more marked than competition between species. Thus, while a floristic list of the region may give the impression of a simple vegetation, all that is truly implied is that the vegetation is composed of a relatively small number of taxa at the specific level. Certainly, this does not necessarily mean that the vegetation is simple since competition, and therefore vegetational structure, may be very great at the sub-specific level.

The flora of northern Saskatchewan has not been extensively collected, the most extensive collections appear to be those of Raup in the vicinity of Lake Athabasca (lat. 59°). Raup's limited collections from the sand dunes on the south shore of Lake Athabasca indicate some form of endemism in this area since several new species of Salix, Deschampsis, Cicuta and Tanacetum have been described from his collections. This suggestion, however, is not entirely consistent with the most plausible explanations of the phytogeography of the region. The short time since the retreat of the last ice sheet and the homogeneity of macroclimate and macrotopography would tend to operate against speciation. At present, plant collections from north central Canada are simply insufficient to resolve this problem. The nature of these endemics and their mode of origin may, in the light of more data, be brought into sharp focus.

Taxonomic studies over the next five years will, therefore, concentrate on making intensive collections of the flora from specific regions. For example, the sand dune area in the vicinity of Pasfield Lake (lat. 58°) appears from geological maps to be similar to the sand areas from which Raup made his collections, and specimens from this and similar areas are essential. From these collections certain problematical genera and species will be intensively studied in the field. Further, the phytosociological work described above will undoubtedly turn up additional puzzling plant groups and a combined phytosociological-taxonomic approach will do much to increase our understanding of the region's vegetation. The importance of the taxonomic studies to the over all research plan as outlined here cannot be over emphasized since all other data must be evaluated in light of what is known about the plant populations inhabiting the region. Therefore, it is important that the taxonomic studies be done in close conjunction with the other phases of the work.

All voucher specimens collected in the implementation of the studies will be deposited in the W.P. Fraser Herbarium, University of Saskatchewan.

While the collection and analysis of plant materials will dominate the first phase of the taxonomic studies to be done in the North, it is only preliminary to experimental work planned for the future. However, to begin experimental work at a time when the flora is so poorly known would necessarily produce results which would be isolated and difficult to interpret.

Four graduate students have been programmed for work on this phase of the study. In spite of the importance of this work to the overall program, it is not possible at this time to be more specific as to the particular taxonomic problems which will engage these students.

B_2. Autecological Studies. In cooperation with Taylor A. Steeves, Department of Biology.

Little beyond cursory data are available as to the autecological characteristics of even the most common plant taxa of the Boreal Forests. The paradox that the Boreal Forest plants, in spite of the fact that they live in an area of excessive water, are morphological and physiological xerophytes has been long recognized in a general way but has been little investigated with the advanced techniques and instrumentation of modern morphology and physiology. The paucity of data or even enlightened speculative theorization as to the methods by which these plants maintain a homeostatic equilibrium with their environment emphasizes the need for work in this long neglected area. One of the major deterrents to these studies, at least on the North American Continent, is the remoteness of the Boreal Forest from major botanical research institutions and the consequent costs of transportation to and from study areas. While this remoteness is no doubt a factor in all botanical research on the Boreal Forest, it is particularly important in morphological and physiological studies where sensitive equipment must be transported long distances over unimproved roads or by aircraft. Since the University of Saskatchewan is located less than 150 miles from undisturbed Boreal Forest, an unusual opportunity is available for relatively economical research in this area.

In the autecological phase of the research, first emphasis will be upon utilizing the phytosociological ordinations described above as frameworks upon which autecological work may be organized. The general behaviour patterns of taxa along various climatic and

edaphic gradients will be known from the phytosociological work. The principal task, therefore, of the autecological studies will be to determine those morphological and physiological characteristics which enable plants to occupy the environments which they do in nature by attempting to find correlations between various morphological and physiological characteristics of the plants and environmental gradients. In early stages of the work, easily detected plant characteristics (e.g. leaf size, leaf shape, chlorophyll content, number and position of stomata, etc.) will be described and correlations sought with various clines and environmental gradients. These data will give good first approximations as to the kinds of characteristics which are of survival value in the various environments of the Boreal Forest and will tell us where the experimental method may be most effectively applied in answering questions concerning the form and function of these plants.

To date, virtually all attention given to the growth characteristics of the Boreal Forest taxa has been by foresters, wildlife surveyors and others interested in the practical aspects of land management. While the techniques developed for measuring growth for these practical purposes have been useful in many ways, they are not always expressed in meaningful biological terms. For example, problems of senescence in forest trees have been considered by foresters to the extent that some characteristics of the phenomena can be recognized and described. However, the morphological and/or physiological causes for senescence have not been investigated. The writers have observed that in northern Saskatchewan senescence in the same species may occur in a much smaller (and perhaps younger) plant in one habitat as opposed to another habitat in the same local area; e.g., black spruce senescence occurs in muskegs much earlier than on upland sites. Obviously, an understanding of the factors which control senescence in forest trees is of great value in understanding the vegetation.

The occurrence of fire in the Boreal Forest is so commonplace that it is considered one of the principal influents in determining the structure of the vegetation. The most conspicuous way in which revegetation following fire is accomplished in these forests is by vegetative reproduction from roots and stems. The mechanisms by which vegetative reproduction is initiated and sustained in vascular plants are, therefore, of importance to an understanding of the vegetation. The phytosociological work will again form an ordinated background against which growth characteristics of these plants may be viewed; these data will give information bearing on the geographical distribution and physiographic occurrences of various growth forms. Experimental studies in both the field and greenhouse will be extensively utilized in this phase of the work.

For implementation, the autecological studies have been programmed in the following way:

Morphological Autecology

a. Gradient analysis studies
    1. The southern Boreal Forest
    2. The northern Boreal Forest

b. Studies on the growth forms of Boreal plants
    3. Growth forms of the forest trees

c. Studies on vegetative reproduction
    4. Vegetative studies on woody species
    5. Vegetative studies on herbaceous species

Physiological Autecology

> There is no plan for extensive work in physiological autecology during the time covered by this plan. Physiological research in the Boreal Forest will be expensive in terms of both man-hours and instrumentation and it is felt that such studies can be more efficiently carried out when the natural occurrences of the taxa, their taxonomy and morphological characteristics are better known.

This phase of the work will include five graduate students. The priority for the problems will be in the general order 1, 3, 4, 5 and 2. As with phytosociological work, first attention will be directed towards studies in the southern regions of the Boreal Forest where advantage may be taken of the existing road systems and emphasis will proceed northward as the studies advance. Two graduate students will begin work on these problems in the spring of 1962 and three additional students are programmed to begin at later dates. These students will work in close cooperation with the phytosociological and taxonomic phases described above.

When the autecological characteristics of the Boreal Forest taxa are better known, more elaborate and refined experimental transplant and greenhouse work will be required. It is proposed that at least two transplant gardens be established in the North - one near La Ronge and one near the northern edge of the forest. The many practical problems concerned in the establishment and maintenance of transplant gardens are realized and, for this reason, it is felt that their further consideration should be delayed until the interpretive work is more advanced. The transplant garden work is mentioned here to alert the Institute for Northern Studies that such work is considered essential in the near future and that serious consideration and planning, but no action, should be undertaken at this time.

C. Paleoecological Studies. In cooperation with Margaret W. Steeves, Department of Geology.

This phase of ecology deals with the history of vegetation and the implied climatic characteristics which accompanied it through periods of geological time. The data which serve as a basis for these studies are derived from the geological record. The fossil record, if carefully interpreted, will give information as to the kinds of plants and animals which occupied a region at the time the containing sediments were deposited. Interpretations of the fossil record are based upon what is known of the ecology of living representatives of the same or closely related taxa; climatic conditions of the time can only be inferred.

Fossils may be divided for convenience into two types: macrofossils and microfossils. Macrofossils are relatively large remnants of plant and animal material such as logs, leaves, cones, skeletons or other organic materials which are recognizable as to their general nature without the aid of optical tools. Identification of these fossils is usually accomplished by making a careful comparison between the fossil material and contemporary material of known origin ; e.g., a fossil leaf may be compared to a similar leaf from a living taxon. It is possible to identify a macrofossil either by a careful examination of its gross external characteristics or by a microscopic examination of its internal structure. As valuable as macrofossils are, their usefulness is greatly restricted by the fact that they are not widespread

in occurrence and that their exposure is dependent upon fortuitous outcroppings of the containing geological strata. Consequently, the macrofossil record through extended periods of geological time is almost always interrupted and incomplete and therefore difficult or impossible to interpret.

By far the most widely used botanical microfossils are pollen grains. Because pollen grains are relatively constant in size and form, genera, and sometimes species, may be positively identified. Wind-borne pollen is deposited over the surface of the earth and that which falls into an environment which permits only a slow rate of oxidation is preserved. Preservation may occur in the sediments of either aquatic or terrestrial environments. If it be assumed that the specific composition of the pollen reaching an area of deposition is a true reflection of the vegetation surrounding that area, and if it be assumed that the chances for fossilization are equal for each pollen grain, it is apparent that the number of grains of various taxa present in a sample taken in modern times will reflect the taxal composition of the vegetation occupying the area at the time of deposition. When such samples are taken in a stratigraphic series from geological deposits, the vegetational history of the area is thought to be reflected in the pollen profile (the per cent of pollen grains of various taxa in a chronological sequence of samples). Correctly or not, these assumptions are now, and have long been, accepted by most investigators in both Europe and North America.

In the early 20th century a long series of studies based on fossil pollen from peat deposits were begun in Europe and a comprehensive and plausible account of the post-glacial history of the vegetation of Europe was constructed. However, attempts to apply European techniques and concepts of pollen analysis to the glaciated areas of North America have met with limited success. The reasons for this are three fold. (1) The flora of Europe is much more simple in terms of numbers of species than that of North America and therefore the data from North America have been much more difficult to interpret. (2) North American investigators have often failed to make the necessary preliminary studies on pollen morphology and pollen survival in the taxa with which they are working. The tendency has been largely to accept the interpretation postulated from work done in Europe. The floras of the two areas are quite distinct, however, and this acceptance seems questionable. (3) The very large geographic area of glaciated terrain in North America and the comparatively small number of workers engaged in these activities have not permitted a comprehensive picture of the general vegetational patterns of post-glacial times to emerge.

The paleoecological work covered by this proposal is designed to supply data bearing on the above. The studies proposed here are divided into three problems:

1. Studies on pollen morphology and survival characteristics of Boreal Forest taxa.

2. The use of indicator species in palynological studies in north central Canada.

3. Palynological studies of cores taken from organic sediments in north central Canada.

These problems will be concerned with studies on the pollen rain reaching a selected area from a vegetation of known distance and measured phytosociological composition.

Studies on the morphological characteristics of pollen grains from Boreal Forest taxa will be initiated and experiments designed to determine the morphological changes which occur in these grains when they are exposed to various natural and simulated environments. This work is made necessary by recent studies in Vermont which have shown that the pollen rain reaching an area is not necessarily a true reflection of the taxal composition of the donor vegetation. Cores from organic sediments will also be studied in an effort to determine the vegetational history of at least a few critical local areas. It is planned that problem 1 be initiated in the spring of 1962 and that problems 2 and 3 be programmed for initiation in the spring of 1964. Again, the work of these students will be closely integrated with the investigations described in earlier sections of this plan.

D. Future Studies After the Spring of 1967

The above program will serve as a basis for studies beyond the period covered by this proposal. Undoubtedly, problems in need of investigation which are not now apparent will come to light in the course of the work. At this time, however, it is of value to suggest the major outlines of the work to be done beyond 1967 so that the present proposal may be seen in its proper context.

Beyond 1967, the phytosociological phase of the work will extend its geographic limits to include the Tundra of north central Canada. Phytosociological work of the detail now in use in the Department of Plant Ecology has not been applied to the Arctic Tundra, although this type of work is already under way in the Alpine Tundra of Colorado. Within the Boreal Forest, detailed distributional patterns of the taxa within local areas, vegetational mapping based on new concepts derived from phytosociological data and the development of more precise phytosociological methods will be emphasized.

The taxonomic work will concern itself with the geographical distribution of various taxa and the phylogenetic relationships between them. Experimental transplant work and studies in cytotaxonomy will be the principal methods employed in this work. It is hoped that at this time it will be possible to begin work on a comprehensive flora of north central Canada.

The autecological investigations in the period after 1967 will be much more experimental in nature than those programmed for the first five years. This work will be more physiological in nature and will include greenhouse and garden experiments on the growth characteristics, mineral nutrition, light requirements, water relationships and productivity of Boreal species.

The paleoecological work during the period following 1967 will devote most of its attention towards an elucidation of the Post-Pleistocene vegetational history of north central Canada.

III. PERSONNEL

In keeping with the dual responsibility of the University, the research plan described here has been developed with attention to both research and the training of researchers. Graduate students have been worked into the plan whenever possible and attention has been given to their special needs and circumstances. The programs in research and teaching carried on by the Departments of Plant Ecology, Biology, Soil Science, Geology and Physics at the University of Saskatchewan, and the close cooperation between these Departments, present excellent opportunities for the training of students in the various sub-disciplines of botany. The plan provides for a total of 17 graduate students over the five years covered in the plan. While most students will probably wish to continue their studies until the Ph.D. degree has been achieved, provision is made for those who elect to terminate their studies with a Master's degree. The number of students programmed for each phase of the work is presented in the appropriate part of the STUDY PLAN.

All work will be directly under faculty supervision and the faculty members will attempt to integrate the various phases of the plan when such integration appears to serve the interests of particular studies. The participating faculty members are:

Ralph L. Dix, B.A., M.S. (Catholic U. of America), Ph.D. (Wisconsin), Associate Professor of Plant Ecology.

Robert T. Coupland, B.S.A. (Manitoba), Ph.D. (Nebraska), Professor and Head of the Department of Plant Ecology.

Taylor A. Steeves, B.S. (Massachusetts), A.M., Ph.D. (Harvard), Associate Professor of Biology.

Margaret W. Steeves, B.A. (Douglas), Ph.D. (Harvard), Research Associate in Geology.

The Curator, W.P. Fraser Herbarium (to be appointed).

Professor Dix will serve as co-ordinator of the program.

The research assistant is needed to give continuity to the field work. His duties are outlined on page 2.

Since a great deal of routine laboratory work will be required in the processing of voucher specimens, reference slides, soil samples, microscopic sections, etc., it is planned to employ two full time technical assistants. Not only will their services relieve the faculty and graduate students of much routine work, but their services will also help standardize certain laboratory procedures. These technicians will be assigned as needed to the various phases of the program.

IV. FACILITIES, EQUIPMENT AND SUPPLIES

The laboratory and greenhouse facilities necessary to carry out the plan are existent in the Departments of Plant Ecology, Biology and Geology on the Saskatoon Campus of the University of Saskatchewan. In addition, the participants will have access to field stations located at La Ronge and Uranium City, Saskatchewan. The field stations will supply housing and laboratory facilities for various field parties throughout the course of the program.

Since the supporting Departments of the University are already actively engaged in work of the type outlined in this plan, considerable laboratory and field equipment is already on hand and it will be made available to the participants by the Departments concerned. However, the increase in the numbers of graduate students resulting from the inauguration of this plan will necessitate the purchase of additional equipment and supplies. Since these are only of the types normally employed in research of the kinds described in this plan, they are not detailed here. They have been carefully considered, however, and provision for them is made in the budget.

V. BUDGET

The criteria used in the calculation of the budget are given below.

Stipends

Graduate students will receive the National Research Council stipend rates of $1940.00 for the first and $2360.00 for succeeding years of graduate study.

The research assistant will receive a salary of $5,000.00 the first year with provision made for yearly increases. This salary compares with the National Research Council rate for post-doctorate fellows of $5,000.00.

Technical assistants will begin employment at $2,400.00, which is the salary suggested by the Personnel Officer of the University, and increases through the years have been programmed.

The participating faculty members will receive no stipends from this program.

Travel

Air travel has been calculated on the Saskatchewan Government Airway rates for flights in the North. These rates are $.50 per mile for a Cessna 180 and $.75 per mile for a Beaver DHC-2. Whenever possible, field parties will be sent in groups so as to keep air travel at a minimum.

Travel by road and subsistence rates are $.11 per mile and $3.50 per day, respectively, which are consistent with the Saskatchewan Department of Agriculture rates.

The needed equipment and supplies have been worked out from estimates made by the investigators based on their experience with similar projects. All equipment and supplies will be available to the entire program, and needless duplication of material will be carefully avoided.

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THE BUDGET

	1962-63	1963-64	1964-65	1965-66	1966-67	Totals
Stipends						
Graduate Students	$13,300	$ 20,000	$ 28,960	$22,200	$17,800	$102,260
Technical Assistants	4,800	5,300	6,700	6,800	7,000	30,600
Research Assistant	5,000	5,300	5,600	5,900	6,200	28,000
Travel						
Air	3,000	4,000	6,000	4,500	3,600	21,100
Car	2,860	3,200	5,050	3,650	2,900	17,660
Subsistence	3,005	4,085	6,080	4,555	3,755	21,480
Equipment	3,675	3,550	2,850	1,900	1,200	13,175
Supplies	1,650	1,700	2,525	1,725	1,525	9,125
Publications Costs	0	200	500	500	400	1,600
Totals	$37,290	$47,135	$ 64,265	$51,730	$43,380	$245,000

STATEMENT ON SOLICITING

We hereby certify that we have not employed or retained a company or person (other than a full time employee) to solicit or secure this grant and agree to furnish information relating thereto as requested by the sponsor's (grantor's) cognizant officer.

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